D.6 TRANSPORTATION ACCIDENTS

The offsite transportation accident analysis considers the impacts of accidents during the transportation of waste by truck or rail. Under accident conditions, impacts to human health and the environment may result from the release and dispersal of radioactive material. Transportation accident impacts have been assessed using accident analysis methodologies developed by the NRC. This section provides an overview of the methodologies, and the reader can obtain a detailed description from the referenced reports (NRC 1977; Fischer et al. 1987; Sprung et al. 2000). Accidents that could potentially breach the shipping container are represented by a spectrum of accident severities and radioactive release conditions. Historically, most transportation accidents involving radioactive materials have resulted in little or no release of radioactive material from the shipping container. Consequently, the analysis of accident risks takes into account a spectrum of accidents ranging from high-probability accidents of low severity to hypothetical high-severity accidents that have a correspondingly low probability of occurrence. This accident analysis calculates the probabilities and consequences from this spectrum of accidents.

To provide DOE and the public with a reasonable assessment of radioactive waste transportation accident impacts, two types of analyses were performed. First, an accident risk assessment was performed that takes into account the probabilities and consequences of a spectrum of potential accident severities using a methodology developed by the NRC (NRC 1977; Fischer et al. 1987; Sprung et al. 2000). For the spectrum of accidents considered in the analysis, accident consequences in terms of collective dose to the population within 80 kilometers (50 miles) were multiplied by the accident probabilities to yield collective dose risk using the RADTRAN 5 computer code (Neuhauser et al. 2000). Second, to represent the maximum reasonably foreseeable impacts to individuals and populations should an accident occur, radiological consequences were calculated for an accident of maximum credible severity in each population zone. An accident is considered credible if its probability of occurrence is greater than 1×10^{-7} per year (1 in 10 million per year). The accident consequence assessment for maximally exposed individuals and population groups was performed using the RISKIND computer code (Yuan et al. 1995).

The impacts for specific alternatives were calculated in units of dose (rem or person-rem). Impacts are further expressed as health risks in terms of estimated latent cancer fatalities in exposed populations. The health risk conversion factors used were derived from International Commission on Radiological Protection Publication 60 (ICRP 1991). The nonradiological impacts from transportation accidents (traffic fatalities) were also estimated.

D.6.1 Transportation Accident Rates

For calculating accident risks and consequences, state-specific accident rates were taken from data provided in Saricks and Tompkins (1999) for rail and heavy combination trucks. For calculating the nonradiological impacts from transportation accidents, state-specific fatality rates were taken from data provided in Saricks and Tompkins (1999) for rail and heavy combination trucks.

D.6.2 Conditional Probabilities and Release Fractions

Accident severity categories for potential radioactive waste transportation accidents are described in three NRC reports: NUREG-0170 (NRC 1977) for radioactive waste in general; a report commonly referred to as the Modal Study (Fischer et al. 1987); and a reassessment of NUREG-0170 (Sprung et al. 2000). The latter two reports address only spent nuclear fuel. The Modal Study represents a refinement of the NUREG-0170 methodology, and the recent reassessment analysis, which compares more recent results to NUREG-0170, represents a further refinement of both studies. Even though none of the radioactive waste assumed to be shipped in this EIS is classified as spent nuclear fuel, many of the modeling techniques developed in Fischer et al. (1987) and Sprung et al. (2000) can be applied to the types of waste that would be shipped from the WVDP site. Thus, this section presents the results of analyses that extend the results presented in the reexamination of the transport risk to fuel types other than spent nuclear fuel.

Each of the risk analyses considers a spectrum of accidents of varying severity. Each first determines the conditional probability that the accident will be of a specified severity. Then, based on the accident environment associated with each severe accident, each models the behavior of the material being shipped and the response of the packaging. The models estimate the fraction of each species of radioactive material that might be released for each of the severe accidents being considered. Each of the NRC risk assessments has considered a different breakdown of the severe accident environment. The analyses presented in NUREG-0170 divides the accident environment into eight accident severity categories. Fischer et al. (1987) represented the severe accident environment as a matrix, with one dimension being midline temperature of the lead in the cask and the other dimension being cask deformation. The matrix contained a total of 20 cases. The most recent analysis (Sprung et al. 2000) also represented the severe accident environment as a matrix, with one dimension being the temperature of the radioactive material and the other being the velocity of impact onto an unyielding surface. The matrix contained 19 cases for the truck accidents and 21 cases for rail accidents. The unique feature of the most recent analysis is the specification of a fire-only case. The NUREG-0170 analyses did not specify the accident environment associated with each of the eight accident severity categories, whereas the later analyses both based their cases on a matrix of fire durations and mechanical impacts on the cask. The result is ultimately reduced to a conditional probability of occurrence for each accident case or category, and a set of radionuclide release fractions for each accident case or category.

Both the Modal Study and Sprung et al. (2000) distinguished among material types that are present in the waste form. In addition to release fractions for particulates, separate release fractions are specified for noble gases, cesium, ruthenium, and any crud that might be present on the external surfaces of the spent nuclear fuel cladding. Rather than carry between 19 and 21 accident severity cases through the analysis, a simple mathematical technique has been used to reduce the accident categories to 6 when estimating the transport accident risk.

The probability for the severity category was estimated using the following formula:

$$P_{Sci} = \sum_{j} P_{Cj}$$

where:

j represents the cases included in severity category i
P_{Cj} is the case j probability
P_{Sci} is the accident severity i probability

The probability weighting of the release fractions is calculated using the following formula:

$$RF_{Sci,m} = \frac{\sum_{j,m} RF_{Cj} * P_{Cj}}{P_{Sci}}$$

The use of the "i" and "j" subscripts in the above equation are the same as those used for the probability calculation. The additional "m" subscript has been added to represent the various material classes. The term "RF" is the fraction of the material in the cask released for a given material type. The two equations above are general and have been used to reduce the accident severity categories in NUREG-0170 from

8 to 6 and, in the case of the HLW and Class B and Class C shipping container analyses, from the 21 rail and 19 truck accident severity cases described by Sprung et al. (2000) to the 6 accident severity categories carried through this assessment. Use of these two equations reduces the level of detail carried into subsequent calculations without changing the overall risk estimate. Tables D-5 through D-10 show the six accident severity categories used to model the transportation accident risk for all the waste materials that may be shipped from the WVDP site.

Table D-5. Conditional Probabilities and Release Fractions for CH-TRU Waste Shipments

Severity Category	Truck		Rail	
	Conditional Probability	Release Fraction	Conditional Probability	Release Fraction
1	0.91	0	0.80	0
2	0.070	8.0×10^{-9}	0.18	2.0×10^{-8}
3	0.016	2.0×10^{-7}	0.018	7.0×10^{-7}
4	2.8×10^{-3}	8.0×10^{-5}	1.8×10^{-3}	8.0×10^{-5}
5	1.1×10^{-3}	2.0×10^{-4}	1.3×10^{-4}	2.0×10^{-4}
6	1.0×10^{-4}	2.0×10^{-4}	7.0×10^{-5}	2.0×10^{-4}

Source: DOE 1990.

Table D-6. Conditional Probabilities and Release Fractions for RH-TRU Waste Shipments

Severity Category	Truck		Rail	
	Conditional Probability	Release Fraction	Conditional Probability	Release Fraction
1	0.99993	0	0.99991	0
2	6.2×10^{-5}	2.6×10^{-5}	3.9×10^{-5}	2.5×10^{-5}
3	5.6×10^{-6}	2.4×10^{-5}	4.9×10^{-5}	8.8×10^{-5}
4	5.2×10^{-7}	2.6×10^{-5}	5.8×10^{-7}	5.3×10^{-4}
5	7.0×10^{-8}	6.2×10^{-5}	1.1×10^{-7}	1.3×10^{-4}
6	2.2×10^{-10}	6.7×10^{-5}	8.5×10^{-10}	2.9×10^{-4}

Source: DOE 1990.

Table D-7. Conditional Probabilities and Release Fractions for HLW Shipments

Severity Category	Truck		Rail	
	Conditional Probability	Release Fraction	Conditional Probability	Release Fraction
1	0.99993	0	0.99991	0
2	6.2×10^{-5}	3.4×10^{-8}	3.9×10^{-5}	6.2×10^{-8}
3	5.6×10^{-6}	0	4.9×10^{-5}	0
4	5.2×10^{-7}	2.4×10^{-7}	5.8×10^{-7}	7.9×10^{-6}
5	7.0×10^{-8}	9.3×10^{-8}	1.1×10^{-7}	9.3×10^{-8}
6	2.2×10^{-10}	3.0×10^{-7}	8.5×10^{-10}	2.7×10^{-6}

Table D-8. Conditional Probabilities and Release Fractions for Class C LLW Drum Cell Waste Shipments

Severity Category	Truck		Rail	
	Conditional Probability	Release Fraction	Conditional Probability	Release Fraction
1	0.93	0	0.93	0
2	0.071	1.2×10^{-5}	0.069	1.2×10^{-5}
3	2.2×10^{-3}	3.1×10^{-5}	1.0×10^{-3}	3.1×10^{-5}
4	7.5×10^{-5}	8.8×10^{-6}	3.7×10^{-3}	3.3×10^{-5}
5	6.9×10^{-4}	5.0×10^{-5}	3.8×10^{-4}	5.9×10^{-5}
6	6.1×10^{-5}	5.7×10^{-5}	1.3×10^{-4}	7.5×10^{-5}

Table D-9. Conditional Probabilities and Release Fractions for Class A Drum and Box and Class B LLW Drum Waste Shipments

Severity Category	Truck		Rail	
	Conditional Probability	Release Fraction	Conditional Probability	Release Fraction
1	0.81	0	0.82	0
2	0.14	1.2×10^{-5}	0.14	1.2×10^{-5}
3	0.028	9.2×10^{-4}	0.019	9.1×10^{-4}
4	1.9×10^{-4}	5.0×10^{-4}	2.5×10^{-5}	5.0×10^{-4}
5	0.019	7.9×10^{-3}	0.015	7.7×10^{-3}
6	1.2×10^{-4}	0.38	9.7×10^{-4}	0.38

Table D-10. Conditional Probabilities and Release Fractions for Class B LLW High-Integrity Containers and Class C LLW Drum and High-Integrity Container Shipments

Severity Category	Truck		Rail	
	Conditional Probability	Release Fraction	Conditional Probability	Release Fraction
1	0.99993	0	0.99991	0
2	6.2×10^{-5}	2.6×10^{-5}	3.9×10^{-5}	2.5×10^{-5}
3	5.6×10^{-6}	2.4×10^{-5}	4.9×10^{-5}	8.8×10^{-5}
4	5.2×10^{-7}	2.6×10^{-5}	5.8×10^{-7}	5.3×10^{-4}
5	7.0×10^{-8}	6.2×10^{-5}	1.1×10^{-7}	1.3×10^{-4}
6	2.2×10^{-10}	6.7×10^{-5}	8.5×10^{-10}	2.9×10^{-4}

In developing the release fractions for the various waste types, the models developed in Sprung et al. (2000) combined separate responses of the waste form, its cladding, the response of the gases internal to the waste form and shipping container, and the shipping container. Waste form release fractions were estimated for the 21 rail and 19 truck cases. For shipping containers used for HLW and Class B and Class C waste, the response for the various accident environments represented by the 19 and 21 cases was assumed to be the same. To estimate the behavior of materials released from the clad to the internals of the packaging, Sprung et al. (2000) developed a deposition and gas expansion model to estimate the fraction of the material in the gas that might be released to the environment. To demonstrate how these models were adapted to one of the WVDP waste types, the modeling of the HLW canister behavior in the accident environment represented by the 21 rail and 19 truck severe accident cases will be described.

The first step was to make the assumption that because glass and ceramics are both brittle solids, both will have similar particulate release fractions when struck during a severe transportation accident. Because a melt temperature of 1,150 degrees Celsius (2,102 degrees Fahrenheit) is used to pour the HLW into the canister, no noble gases would be present in the waste form. Furthermore, any cesium or ruthenium present would be tightly bound to the boron and silicon in the HLW so they would behave as particulates instead of volatile species. Lastly, there would be no crud.

The second step was to replace the clad failure rate used in Sprung et al. (2000) for spent nuclear fuel with a canister failure model. Based on impact tests on simulated HLW canisters, it was estimated that 20 percent of the canisters would fail if they impacted a surface at between 48 and 97 kilometers (30 and 60 miles) per hour, 70 percent would fail if they impacted the surface at between 97 and 145 kilometers (60 and 90 miles) per hour, and all would fail if they impacted the surface at speeds in excess of 145 kilometers (90 miles) per hour. Furthermore, assuming the canister was sealed at room temperature, a stress analysis performed on the canister showed that it would not fail from pressure buildup when exposed to fires as high as 1,000 degrees Celsius (1,832 degrees Fahrenheit). This was the highest temperature considered in any of the cases modeled by Sprung et al. (2000).

The final two parts of the Sprung et al. (2000) analysis were deposition and gas displacement models. The deposition model estimated the fraction of the material released from the spent nuclear fuel clad that is deposited on the inside surfaces of the cask and clad and therefore not available for immediate release. The gas displacement model considers the pressure buildup inside the cask and the fraction of the gas that must be released to reduce the pressure inside the cask to atmospheric pressure. The model assumes the fraction of the radioactive material released from the cask is the same as the fraction of the internal gases that must be released from the cask to reduce the internal pressure in the cask to atmospheric pressure. In the modeling of the HLW releases, no changes were made to the gas displacement model. The source of the displacement was assumed to be the 1.9 atmosphere pressure internal to the canister during shipment. This pressure is based on the assumption that the canister was sealed at room temperature and operates at 300 degrees Celsius (572 degrees Fahrenheit) during shipment.

Once the 19 truck cases and the 21 rail cases have been modeled for the waste forms, the resultant conditional probabilities and release fractions were reduced to the 6 accident severity categories shown in Tables D-5 to D-10. While different assumptions were made, a similar process was performed to estimate the conditional probabilities and release fractions for the other waste forms. For the Class C drum cell waste shipments, the waste is contained in a grout matrix that is assumed to be have impact properties that are similar to those for the HLW and ceramic fuel. For the thermal behavior, the grout will basically turn back to powder, losing all its bound water, at 600° Celsius (1,112° Fahrenheit). A thermal model of a waste drum was used to estimate the fraction of the grout decomposed as a function of the fire duration. The conditional fire probabilities were the same as those used for the HLW, and the thermal release fraction for the decomposed grout used the release fraction for aggregate taken from DOE (1994). The results for this waste form are shown in Table D-8. For the waste in Type B containers, the HLW canister model was modified in two ways. First, the effect of the canister was removed, placing all of the release limits on the performance of the Type B packaging in the accident environment. This packaging was assumed to perform as the lead cask performed in Sprung et al. (2000). The other change was to use release fractions that are consistent with the type of waste being shipped, a surface-contaminated solid. These release fractions and conditional probabilities are shown in Tables D-6 and D-10. For the Class A waste shipped in drums and boxes, a crush model was used to estimate the fraction of the drums failed at various impact velocities, and the release fractions for combustible solids presented in DOE (1994) were thought to be most representative of these wastes. The release fractions and conditional probabilities for these waste forms are presented in Table D-9.

The RADTRAN 5 computer code was used to estimate accident unit risk factors (units of person-rem per kilometer per person per square kilometer) for each radionuclide in the various waste forms. An Access database was used to combine the unit risk factors with data on conditional probabilities, release fractions, accident rates, population densities, route distances, and radionuclide inventories to calculate the total accident dose risk for each alternative examined in the EIS. For a given alternative, the accident unit risk factors were first multiplied by the number of shipment kilometers through each population zone being traversed by the waste shipments and then by the population density associated with that population zone. By summing over all population zones traversed by the waste form and then over all waste forms being considered, the total accident dose risk for each of the alternatives has been obtained.

D.6.3 Shipment Inventories

The radionuclide inventories in Classes A, B, and C LLW were estimated from the five radionuclide mixes in Table 3-6 of Marschke (2001). The five radionuclide mixes were converted to radionuclide concentrations and scaled to arrive at the maximum radionuclide concentrations that were Class A, B, or C waste. To determine which of the five mixes for each waste class had the greatest radiological hazard, the radionuclide concentration was divided by the A_2 value for each radionuclide from 10 CFR 71 and summed for each mix. The mix with the largest sum represents the mix with the largest radiological hazard; this mix was then used in the transportation risk assessment. The radionuclide concentrations were then converted to container inventories, which are presented in Table D-11. Radionuclide inventories for Drum Cell waste are presented in Table D-12.

The radionuclide inventories for CH-TRU waste was taken from DOE (1997a) and are listed in Table D-13. The radionuclide inventory for RH-TRU waste was based on the radionuclide distribution for spent nuclear fuel, scaled to 2 curies of plutonium per 55-gallon drum, or 20 curies of plutonium per 10 drums, which is the limit for the shipping container. The radionuclide inventory is listed in Table D-13. The radionuclide inventory for HLW was taken from DOE (2002a) and is listed in Table D-14.

D.6.4 Atmospheric Conditions

Because it is impossible to predict the specific location of an offsite transportation accident, generic atmospheric conditions were selected for the risk and consequence assessments. For accident risk assessment, neutral weather conditions (Pasquill Stability Class D) were assumed. Neutral weather conditions are typified by moderate windspeeds, vertical mixing within the atmosphere, and good dispersion of atmospheric contaminants. Because neutral meteorological conditions compose the most frequently occurring atmospheric stability condition in the United States, these conditions are most likely to be present in the event of an accident involving a radioactive waste shipment. On the basis of observations from National Weather Service surface meteorological stations at 177 locations in the United States, on an annual average, neutral conditions (Pasquill Class C and D) occur 59 percent of the time, while stable (Pasquill Class E and F) and unstable (Pasquill Class A and B) conditions occur 33 percent and 8 percent of the time, respectively (CRWMS M&O 1999).

For the accident consequence assessment, doses were assessed under stable (Class F with 0.89 meter [2.92 feet] per second windspeed) atmospheric conditions. Stable weather conditions are typified by low windspeeds, very little vertical mixing within the atmosphere, and poor dispersion of atmospheric contaminants. Class F meteorology in combination with windspeeds of 0.89 meter per second generally occur no more than 12 percent of the time. Results calculated for stable conditions represent a worst-case weather situation.

Table D-11. Class A, B, and C Container Inventories[a]

Nuclide	Class A LLW		Class B LLW		Class C LLW	
	Drum[b] Inventory	Box Inventory	Drum Inventory	HIC[c] Inventory	Drum Inventory	HIC[c] Inventory
Hydrogen-3	1.56×10^{-6}	5.50×10^{-8}	6.76×10^{-8}	8.83×10^{-7}	6.76×10^{-7}	8.83×10^{-6}
Carbon-14	6.49×10^{-6}	7.23×10^{-8}	8.88×10^{-8}	1.16×10^{-6}	8.88×10^{-7}	1.16×10^{-5}
Iron-55	0	5.57×10^{-7}	6.84×10^{-7}	8.95×10^{-6}	6.84×10^{-6}	8.95×10^{-5}
Nickel-59	0	1.24×10^{-6}	1.52×10^{-6}	1.99×10^{-5}	1.52×10^{-5}	1.99×10^{-4}
Nickel-63	0	1.66×10^{-4}	2.04×10^{-4}	2.66×10^{-3}	2.04×10^{-3}	0.0266
Cobalt-60	0	1.16×10^{-8}	1.43×10^{-8}	1.87×10^{-7}	1.43×10^{-7}	1.87×10^{-6}
Strontium-90	7.02×10^{-4}	0.070	0.086	1.12	0.86	11.2
Technetium-99	2.49×10^{-7}	6.26×10^{-6}	7.68×10^{-6}	1.00×10^{-4}	7.68×10^{-5}	1.00×10^{-3}
Iodine-129	5.21×10^{-10}	0	0	0	0	0
Cesium-137	8.96×10^{-4}	0.798	0.98	12.8	9.80	128
Europium-154	5.48×10^{-6}	7.32×10^{-4}	8.99×10^{-4}	0.0118	8.99×10^{-3}	0.118
Actinium-227	5.85×10^{-10}	9.44×10^{-12}	1.16×10^{-11}	1.52×10^{-10}	1.16×10^{-10}	1.52×10^{-9}
Radium-228	3.43×10^{-11}	1.57×10^{-17}	1.93×10^{-17}	2.52×10^{-16}	1.93×10^{-16}	2.52×10^{-15}
Protactinium-231	2.21×10^{-9}	4.55×10^{-12}	5.58×10^{-12}	7.30×10^{-11}	5.58×10^{-11}	7.30×10^{-10}
Thorium-232	2.37×10^{-10}	9.25×10^{-17}	1.14×10^{-16}	1.49×10^{-15}	1.14×10^{-15}	1.49×10^{-14}
Uranium-232	4.09×10^{-6}	6.09×10^{-8}	7.48×10^{-8}	9.78×10^{-7}	7.48×10^{-7}	9.78×10^{-6}
Uranium-233	8.75×10^{-6}	1.08×10^{-7}	1.33×10^{-7}	1.74×10^{-6}	1.33×10^{-6}	1.74×10^{-5}
Uranium-234	4.34×10^{-7}	6.27×10^{-8}	7.70×10^{-8}	1.01×10^{-6}	7.70×10^{-7}	1.01×10^{-5}
Uranium-235	8.43×10^{-8}	1.40×10^{-9}	1.71×10^{-9}	2.24×10^{-8}	1.71×10^{-8}	2.24×10^{-7}
Uranium-238	9.49×10^{-7}	1.24×10^{-8}	1.52×10^{-8}	1.99×10^{-7}	1.52×10^{-7}	1.99×10^{-6}
Neptunium-237	3.71×10^{-9}	4.70×10^{-7}	5.77×10^{-7}	7.55×10^{-6}	5.77×10^{-6}	7.55×10^{-5}
Plutonium-238	2.79×10^{-4}	8.80×10^{-5}	1.08×10^{-4}	1.41×10^{-3}	1.08×10^{-3}	0.0141
Plutonium-239	3.92×10^{-4}	2.10×10^{-5}	2.58×10^{-5}	3.38×10^{-4}	2.58×10^{-4}	3.38×10^{-3}
Plutonium-240	2.78×10^{-4}	2.10×10^{-5}	2.58×10^{-5}	3.38×10^{-4}	2.58×10^{-4}	3.38×10^{-3}
Plutonium-241	0.011	7.62×10^{-4}	9.36×10^{-4}	0.0122	9.36×10^{-3}	0.122
Plutonium-242	2.27×10^{-7}	1.08×10^{-7}	1.33×10^{-7}	1.74×10^{-6}	1.33×10^{-6}	1.74×10^{-5}
Americium-241	2.87×10^{-5}	7.33×10^{-4}	9.00×10^{-4}	0.0118	9.00×10^{-3}	0.118
Americium-243	8.70×10^{-7}	8.61×10^{-6}	1.06×10^{-5}	1.38×10^{-4}	1.06×10^{-4}	1.38×10^{-3}
Curium-242	1.05×10^{-16}	5.10×10^{-6}	6.26×10^{-6}	8.19×10^{-5}	6.26×10^{-5}	8.19×10^{-4}
Curium-243	1.54×10^{-8}	7.97×10^{-5}	9.78×10^{-5}	1.28×10^{-3}	9.78×10^{-4}	0.0128
Curium-244	4.21×10^{-7}	7.97×10^{-5}	9.78×10^{-5}	1.28×10^{-3}	9.78×10^{-4}	0.0128

a. All inventories presented in curies.
b. Also used for mixed LLW shipment inventory.
c. HIC = high-integrity container

D.6.5 Population Density Zones

Three population density zones (rural, suburban, and urban) were used for the offsite population risk assessment. These zones respectively correspond to three mean population densities of 6, 719, and 3,861 persons per square kilometer. The actual population densities in the three zones were based on an aggregation of the twelve population density zones provided in the WebTRAGIS output and on data from the 2000 census.

Table D-12. Drum Cell Waste Container Inventory

Nuclide	Drum Inventory (in curies)
Hydrogen-3	1.3×10^{-4}
Carbon-14	3.6×10^{-4}
Cobalt-60	6.0×10^{-8}
Nickel-63	3.5×10^{-5}
Strontium-90	0.027
Technetium-99	0.11
Antimony-125	1.0×10^{-4}
Iodine-129	1.8×10^{-5}
Cesium-137	0.021
Neptunium-237	4.3×10^{-5}
Plutonium-238	5.9×10^{-3}
Plutonium-239	1.2×10^{-3}
Plutonium-240	9.4×10^{-4}
Plutonium-241	0.067
Americium-241	1.4×10^{-3}
Plutonium-242	1.2×10^{-6}
Curium-242	8.6×10^{-12}

Table D-13. TRU Waste Container Inventories[a]

Nuclide	CH-TRU Waste Drum Inventory	RH-TRU Waste Drum Inventory
Cobalt-60	4.6×10^{-5}	0
Strontium-90	7.1×10^{-4}	3.8
Cesium-137	7.1×10^{-4}	4.1
Thorium-228	0	1.2×10^{-3}
Uranium-232	0	1.2×10^{-3}
Uranium-233	0	0
Uranium-235	0	0
Uranium-238	0	0
Plutonium-238	71	0.26
Plutonium-239	1.1	0.073
Plutonium-240	0.30	0.055
Plutonium-241	14	1.6
Plutonium-242	4.9×10^{-5}	0
Americium-241	0.26	0.089
Americium-242	0	6.2×10^{-4}
Americium-242m	0	6.2×10^{-4}
Americium-243	0	3.9×10^{-3}
Curium-244	0	8.1×10^{-3}

a. All inventories presented in curies.

Table D-14. HLW Canister Inventory

Nuclide	Canister Inventory[a]
Actinium-227	0.046
Americium-241	200
Americium-242m	1.0
Americium-243	1.3
Carbon-14	0.53
Curium-242	0.84
Curium-243	0.28
Curium-244	11
Curium-245	3.4×10^{-3}
Curium-246	3.9×10^{-4}
Cesium-134	4.4×10^{-3}
Cesium-135	0.62
Cesium-137	16,000
Hydrogen-3	0.078
Iodine-129	8.1×10^{-4}
Niobium-93m	0.95
Neptunium-237	0.092
Protactinium-231	0.059
Palladium-107	0.042
Plutonium-238	27
Plutonium-239	6.4
Plutonium-240	4.7
Plutonium-241	95
Plutonium-242	6.4×10^{-3}
Radium-228	6.3×10^{-3}
Ruthenium-106	1.9×10^{-9}
Selenium-79	0.23
Samarium-151	270
Tin-126	0.4
Strontium-90	14,000
Technetium-99	6.5
Thorium-229	8.9×10^{-4}
Thorium-230	2.3×10^{-4}
Thorium-232	6.3×10^{-3}
Uranium-232	0.023
Uranium-233	0.037
Uranium-234	0.019
Uranium-235	3.9×10^{-4}
Uranium-236	1.1×10^{-3}
Uranium-238	3.3×10^{-3}
Zirconium-93	1.1
Nickel-59	0.41
Nickel-63	27

Source: DOE 2002a.
a. All inventories presented in curies.

D.6.6 Exposure Pathways

Radiological doses were calculated for an individual located near the scene of the accident and for populations within 80 kilometers (50 miles) of the accident. Rural, suburban, and urban population densities were assessed. Dose calculations considered a variety of exposure pathways, including inhalation and direct exposure (cloudshine) from the passing cloud, ingestion of contaminated crops, direct exposure (groundshine) from radioactivity deposited on the ground, and inhalation of resuspended radioactive particles from the ground.

D.6.7 Health Risk Conversion Factors

The following health risk conversion factors used to estimate latent cancer fatalities from radiological exposures were from the Interagency Steering Committee on Radiation Standards (DOE 2002b): 6×10^{-4} and 5×10^{-4} latent cancer fatalities per person-rem for members of the public and workers, respectively. Although latent cancer fatalities are the predominant health risk associated with low-level radiation doses (that is, doses below the thresholds for acute effects), they are not the only potential detrimental health effect. Risks of other delayed health effects such as non-fatal cancers and hereditary effects should also be acknowledged. International Commission on Radiological Protection Publication 60 (ICRP 1991) has estimated that the total risk of detrimental health effects are 7.3×10^{-4} and 5.6×10^{-4} total detrimental health effects per person-rem for members of the public and workers, respectively.

D.7 RESULTS

D.7.1 Transportation Impacts

No Action Alternative. Table D-15 lists the transportation impacts under the No Action Alternative. If trucks were used to ship the radioactive waste, an estimated 0.034 to 0.041 fatality would occur. The range of total fatalities is based on the minimum and maximum total fatalities for each waste type. Of that, about 60 percent would be from nonradiological traffic accidents and about 10 percent would be from nonradiological pollutants (diesel exhaust and fugitive dust).

Table D-15. Transportation Impacts Under the No Action Alternative

Waste Type	Destination	Incident-Free Public (person-rem)	Incident-Free Worker (person-rem)	Radiological Accident Dose Risk (person-rem)	Incident-Free Public (LCFs)	Incident-Free Worker (LCFs)	Radiological Accident Risk (LCFs)	Pollution Health Effects	Traffic Fatalities	Total Fatalities
Truck										
Class A	Envirocare	15	23	0.11	9.2×10^{-3}	0.011	6.9×10^{-5}	2.1×10^{-3}	0.011	0.034
Class A	Hanford	19	27	0.12	0.011	0.014	7.4×10^{-5}	2.3×10^{-3}	0.014	0.041
Class A	NTS	19	27	0.14	0.011	0.013	8.5×10^{-5}	2.8×10^{-3}	0.013	0.041
Total Truck Fatalities: 0.034 – 0.041										
Rail										
Class A	Envirocare	27	24	0.45	0.016	0.012	2.7×10^{-4}	3.0×10^{-3}	9.8×10^{-3}	0.042
Class A	Hanford	28	26	0.49	0.017	0.013	3.0×10^{-4}	3.1×10^{-3}	0.012	0.046
Class A	NTS	28	32	0.45	0.017	0.016	2.7×10^{-4}	3.0×10^{-3}	0.012	0.049
Total Rail Fatalities: 0.042 – 0.049										

Acronyms: LCFs = latent cancer fatalities; NTS = Nevada Test Site. The range of total fatalities is based on the minimum and maximum total fatalities for each waste type.

If trains were used, an estimated 0.042 to 0.049 fatality would occur. About 70 percent would be from nonradiological traffic accidents and about 20 percent would be from nonradiological pollutants (diesel exhaust and fugitive dust).

Alternative A. Table D-16 lists the transportation impacts under Alternative A. If trucks were used to ship the radioactive waste, an estimated 0.79 to 0.82 fatality would occur. The range of total fatalities is based on the minimum and maximum total fatalities for each waste type. Of that, about 30 percent would be from nonradiological traffic accidents and about 15 percent would be from nonradiological air pollutants.

If trains were used, an estimated 0.60 to 0.68 fatality would occur. Of that, about 30 percent would be from nonradiological traffic accidents and about 20 percent would be from nonradiological air pollutants.

Alternative B. Table D-17 lists the transportation impacts under Alternative B. If trucks were used to ship the radioactive waste, an estimated 0.84 to 0.93 fatality would occur. The range of total fatalities is based on the minimum and maximum total fatalities for each waste type. Of that, about 35 percent would be from nonradiological traffic accidents and about 15 percent would be from nonradiological air pollutants.

If trains were used, an estimated 0.66 to 0.79 fatality would occur. Of that, about 30 percent would be from nonradiological traffic accidents and about 15 percent would be from nonradiological air pollutants.

D.7.2 Incident-Free Radiation Doses to Maximally Exposed Individuals

No Action Alternative. Table D-18 lists the incident-free radiation doses for the maximally exposed individual scenarios under the No Action Alternative. If trucks were used to ship the waste, the maximally exposed worker would be a driver who would receive a radiation dose of about 250 mrem per year based on driving a truck carrying Class A LLW for about 700 hours per year. This is equivalent to a probability of a latent cancer fatality of about 1.3×10^{-4}.

Under the No Action Alternative, the maximally exposed member of the public would be a person working at a service station who would receive a radiation dose of about 0.10 mrem per year. This is equivalent to a probability of a latent cancer fatality of about 6.0×10^{-8}.

If trains were used to ship the waste, the maximally exposed worker would be an inspector. This worker would receive a radiation dose of about 1.9 mrem per year. This is equivalent to a probability of a latent cancer fatality of about 9.5×10^{-7}. The maximally exposed member of the public was a railyard worker who was not directly involved with handling the railcars. This person would receive a radiation dose of about 0.35 mrem per year. This is equivalent to a probability of a latent cancer fatality of about 2.1×10^{-7}.

Alternative A. Table D-18 lists the incident-free radiation doses for the maximally exposed individual scenarios under Alternative A. If trucks were used to ship the waste, the maximally exposed worker would be a driver who would receive a radiation dose of about 2,000 mrem per year based on driving a truck for 1,000 hours per year. This is equivalent to a probability of a latent cancer fatality of about 1.0×10^{-3}.

Table D-16. Transportation Impacts Under Alternative A

Waste Type	Destination	Incident-Free Public (person-rem)	Incident-Free Worker (person-rem)	Radiological Accident Dose Risk (person-rem)	Incident-Free Public (LCFs)	Incident-Free Worker (LCFs)	Radiological Accident Risk (LCFs)	Pollution Health Effects	Traffic Fatalities	Total Fatalities
Truck										
Class A	Envirocare	41	62	0.23	0.025	0.031	1.4×10^{-4}	5.7×10^{-3}	0.030	0.092
	Hanford Site	50	74	0.24	0.030	0.037	1.5×10^{-4}	6.3×10^{-3}	0.038	0.11
	NTS	51	71	0.28	0.031	0.036	1.7×10^{-4}	7.6×10^{-3}	0.036	0.11
Class B	Hanford Site	47	130	1.4×10^{-3}	1.4×10^{-3}	0.028	0.065	5.9×10^{-3}	0.035	0.13
	NTS	48	120	1.6×10^{-3}	1.6×10^{-3}	0.029	0.062	7.1×10^{-3}	0.034	0.13
Class C	Hanford Site	140	400	9.1×10^{-4}	0.087	0.20	5.5×10^{-7}	0.018	0.11	0.41
	NTS	150	380	1.1×10^{-3}	0.089	0.19	6.5×10^{-7}	0.022	0.10	0.41
CH-TRU	WIPP	14	20	1.2	8.3×10^{-3}	0.010	7.5×10^{-4}	2.3×10^{-3}	0.012	0.033
RH-TRU	WIPP	11	27	1.2×10^{-5}	6.5×10^{-3}	0.013	7.5×10^{-9}	2.2×10^{-3}	0.011	0.033
MLLW	Envirocare	1.3	1.9	0.017	7.7×10^{-4}	9.5×10^{-4}	1.0×10^{-5}	1.8×10^{-4}	9.2×10^{-4}	2.8×10^{-3}
	Hanford	1.5	2.3	0.019	9.2×10^{-4}	1.1×10^{-3}	1.1×10^{-5}	1.9×10^{-4}	1.2×10^{-3}	3.4×10^{-3}
	NTS	1.6	2.2	0.022	9.5×10^{-4}	1.1×10^{-3}	1.3×10^{-5}	2.3×10^{-4}	1.1×10^{-3}	3.4×10^{-3}
HLW	Repository	34	88	1.6×10^{-3}	0.020	0.044	9.7×10^{-7}	5.8×10^{-3}	0.024	0.094
										Total Truck Fatalities: 0.79 – 0.82
Rail										
Class A	Envirocare	73	65	0.88	0.044	0.033	5.3×10^{-4}	8.0×10^{-3}	0.026	0.11
	Hanford Site	74	70	0.97	0.045	0.035	5.8×10^{-4}	8.2×10^{-3}	0.034	0.12
	NTS	76	87	0.88	0.046	0.044	5.3×10^{-4}	8.1×10^{-3}	0.033	0.13
Class B	Hanford Site	70	66	5.6×10^{-3}	0.042	0.033	3.4×10^{-6}	3.9×10^{-3}	0.016	0.095
	NTS	71	90	5.1×10^{-3}	0.043	0.045	3.1×10^{-6}	3.8×10^{-3}	0.017	0.11
Class C	Hanford Site	220	200	2.0×10^{-3}	0.13	0.10	1.2×10^{-6}	0.012	0.049	0.29
	NTS	220	280	1.8×10^{-3}	0.13	0.14	1.1×10^{-6}	0.012	0.053	0.34
CH-TRU	WIPP	14	16	0.33	8.3×10^{-3}	8.1×10^{-3}	2.0×10^{-4}	3.4×10^{-3}	0.018	0.038
RH-TRU	WIPP	11	13	4.0×10^{-5}	6.6×10^{-3}	6.4×10^{-3}	2.4×10^{-8}	8.0×10^{-4}	4.2×10^{-3}	0.018
MLLW	Envirocare	2.2	2.0	0.068	1.3×10^{-3}	1.0×10^{-3}	4.1×10^{-5}	2.4×10^{-4}	8.1×10^{-4}	3.4×10^{-3}
	Hanford	2.3	2.2	0.075	1.4×10^{-3}	1.1×10^{-3}	4.5×10^{-5}	2.5×10^{-4}	1.0×10^{-3}	3.8×10^{-3}
	NTS	2.3	2.7	0.068	1.4×10^{-3}	1.3×10^{-3}	4.1×10^{-5}	2.5×10^{-4}	1.0×10^{-3}	4.0×10^{-3}
HLW	Repository	13	28	4.9×10^{-4}	7.6×10^{-3}	0.014	3.0×10^{-7}	4.2×10^{-3}	0.019	0.045
										Total Rail Fatalities: 0.60 – 0.68

Acronyms: LCFs = latent cancer fatalities; CH-TRU = contact-handled transuranic waste; RH-TRU = remote-handled transuranic waste; MLLW = mixed low-level waste; HLW = high-level radioactive waste; NTS = Nevada Test Site; WIPP = Waste Isolation Pilot Plant. The range of total fatalities is based on the minimum and maximum total fatalities for each waste type.

Table D-17. Transportation Impacts Under Alternative B

Waste Type	Destination	Incident-Free Public (person-rem)	Incident-Free Worker (person-rem)	Radiological Accident Dose Risk (person-rem)	Incident-Free Public (LCFs)	Incident-Free Worker (LCFs)	Radiological Accident Risk (LCFs)	Pollution Health Effects	Traffic Fatalities	Total Fatalities
Truck										
Class A	Envirocare	41	62	0.23	0.025	0.031	1.4×10^{-4}	5.7×10^{-3}	0.030	0.092
	Hanford Site	50	74	0.24	0.030	0.037	1.5×10^{-4}	6.3×10^{-3}	0.038	0.11
	NTS	51	71	0.28	0.031	0.036	1.7×10^{-4}	7.6×10^{-3}	0.036	0.11
Class B	Hanford Site	47	130	1.4×10^{-3}	0.028	0.065	8.2×10^{-7}	5.9×10^{-3}	0.035	0.13
	NTS	48	120	1.6×10^{-3}	0.029	0.062	9.4×10^{-7}	7.1×10^{-3}	0.034	0.13
Class C	Hanford Site	140	400	9.1×10^{-4}	0.087	0.20	5.5×10^{-7}	0.018	0.11	0.41
	NTS	150	380	1.1×10^{-3}	0.089	0.19	6.5×10^{-7}	0.022	0.10	0.41
CH-TRU	SRS → WIPP	15	25	1.7	8.8×10^{-3}	0.012	1.0×10^{-3}	2.7×10^{-3}	0.015	0.040
	INEEL → WIPP	18	32	1.1	0.011	0.016	6.7×10^{-4}	2.5×10^{-3}	0.016	0.046
	ORNL → WIPP	13	23	1.1	7.7×10^{-3}	0.012	6.4×10^{-4}	2.2×10^{-3}	0.012	0.034
	Hanford → WIPP	22	38	1.3	0.013	0.019	7.8×10^{-4}	3.0×10^{-3}	0.020	0.056
RH-TRU	SRS → WIPP	12	31	1.7×10^{-5}	6.9×10^{-3}	0.015	1.0×10^{-8}	2.5×10^{-3}	0.014	0.039
	INEEL → WIPP	14	41	1.2×10^{-5}	8.4×10^{-3}	0.021	7.3×10^{-9}	2.4×10^{-3}	0.015	0.046
	ORNL → WIPP	10	29	1.1×10^{-5}	6.1×10^{-3}	0.014	6.4×10^{-9}	2.0×10^{-3}	0.011	0.034
	Hanford → WIPP	17	50	1.4×10^{-5}	0.010	0.025	8.4×10^{-9}	2.8×10^{-3}	0.019	0.057
MLLW	Envirocare	1.3	1.9	0.017	7.7×10^{-4}	9.5×10^{-4}	1.0×10^{-5}	1.8×10^{-4}	9.2×10^{-4}	2.8×10^{-3}
	Hanford Site	1.5	2.3	0.019	9.2×10^{-4}	1.1×10^{-3}	1.1×10^{-5}	1.9×10^{-4}	1.2×10^{-3}	3.4×10^{-3}
	NTS	1.6	2.2	0.022	9.5×10^{-4}	1.1×10^{-3}	1.3×10^{-5}	2.3×10^{-4}	1.1×10^{-3}	3.4×10^{-3}
HLW	SRS → Repository	53	130	4.3×10^{-3}	0.032	0.067	2.6×10^{-6}	9.6×10^{-3}	0.047	0.16
	Hanford → Repository	50	140	2.3×10^{-3}	0.030	0.069	1.4×10^{-6}	8.0×10^{-3}	0.037	0.14
										Total Truck Fatalities: 0.84 – 0.93

Table D-17. Transportation Impacts Under Alternative B (cont)

Waste Type	Destination	Incident-Free		Radiological Accident Dose Risk (person-rem)	Incident-Free		Radiological Accident Risk (LCFs)	Pollution Health Effects	Traffic Fatalities	Total Fatalities
Rail										
Class A	Envirocare	73	65	0.88	0.044	0.033	5.3×10^{-4}	8.0×10^{-3}	0.026	0.11
	Hanford Site	74	70	0.97	0.045	0.035	5.8×10^{-4}	8.2×10^{-3}	0.034	0.12
	NTS	76	87	0.88	0.046	0.044	5.34×10^{-4}	8.1×10^{-3}	0.033	0.13
Class B	Hanford Site	70	66	5.6×10^{-3}	0.042	0.033	3.4×10^{-6}	3.9×10^{-3}	0.016	0.095
	NTS	71	90	5.1×10^{-3}	0.043	0.045	3.1×10^{-6}	3.8×10^{-3}	0.017	0.11
Class C	Hanford Site	220	200	2.0×10^{-3}	0.13	0.10	1.2×10^{-6}	0.012	0.049	0.29
	NTS	220	280	1.8×10^{-3}	0.13	0.14	1.1×10^{-6}	0.012	0.053	0.34
CH-TRU	SRS → WIPP	23	30	0.48	0.014	0.015	2.9×10^{-4}	5.8×10^{-3}	0.037	0.072
	INEEL → WIPP	23	32	0.57	0.014	0.016	3.4×10^{-4}	5.8×10^{-3}	0.023	0.059
	ORNL → WIPP	21	29	0.42	0.012	0.015	2.5×10^{-4}	5.1×10^{-3}	0.022	0.055
	Hanford → WIPP	27	35	0.72	0.016	0.017	4.3×10^{-4}	6.7×10^{-3}	0.032	0.073
RH-TRU	SRS → WIPP	18	24	5.1×10^{-5}	0.011	0.012	3.1×10^{-8}	1.4×10^{-3}	8.8×10^{-3}	0.033
	INEEL → WIPP	18	25	6.7×10^{-5}	0.011	0.013	4.0×10^{-8}	5.4×10^{-3}	0.021	0.050
	ORNL → WIPP	16	23	4.9×10^{-5}	9.8×10^{-3}	0.011	2.9×10^{-8}	4.8×10^{-3}	0.021	0.047
	Hanford → WIPP	21	27	8.3×10^{-5}	0.013	0.014	5.0×10^{-8}	6.3×10^{-3}	0.030	0.063
MLLW	Envirocare	2.2	2.0	0.068	1.3×10^{-3}	1.0×10^{-3}	4.1×10^{-5}	2.4×10^{-4}	8.1×10^{-4}	3.4×10^{-3}
	Hanford Site	2.3	2.2	0.075	1.4×10^{-3}	1.1×10^{-3}	4.5×10^{-5}	2.5×10^{-4}	1.0×10^{-3}	3.8×10^{-3}
	NTS	2.3	2.7	0.068	1.4×10^{-3}	1.3×10^{-3}	4.1×10^{-5}	2.5×10^{-4}	1.0×10^{-3}	4.0×10^{-3}
HLW	SRS → Repository	17	42	5.1×10^{-4}	0.010	0.021	3.0×10^{-7}	6.1×10^{-3}	0.035	0.072
	Hanford → Repository	16	42	6.5×10^{-4}	9.4×10^{-3}	0.021	3.9×10^{-7}	5.3×10^{-3}	0.030	0.066
										Total Rail Fatalities: 0.66 – 0.79

Acronyms: LCFs = latent cancer fatalities; CH-TRU = contact-handled transuranic waste; RH-TRU = remote-handled transuranic waste; MLLW = mixed low-level waste; HLW = high-level radioactive waste; SRS = Savannah River Site; HF = Hanford Site; WIPP = Waste Isolation Pilot Plant; NTS = Nevada Test Site; INEEL = Idaho National Engineering and Environmental Laboratory; ORNL = Oak Ridge National Laboratory. The range of total fatalities is based on the minimum and maximum total fatalities for each waste type.

Table D-18. Incident-Free Radiation Doses for the Maximally Exposed Individual Scenarios

Scenario	No Action Alternative	Alternative A	Alternative B
Truck			
Service station worker (member of the public)	0.10 mrem/yr (6.0×10^{-8} LCFs)	19 mrem/yr (1.1×10^{-5} LCFs)	19 mrem/yr (1.1×10^{-5} LCFs)
Individual in traffic jam (member of the public)	0.50 mrem (3.0×10^{-7} LCFs)	8.2 mrem (4.9×10^{-6} LCFs)	8.2 mrem (4.9×10^{-6} LCFs)
Nearby resident (member of the public)	1.1×10^{-4} mrem/yr (6.6×10^{-11} LCFs)	0.022 mrem/yr (1.3×10^{-8} LCFs)	0.022 mrem/yr (1.3×10^{-8} LCFs)
Driver (occupational)	250 mrem/yr (1.3×10^{-4} LCFs)	2,000 mrem/yr (1.0×10^{-3} LCFs)	2,000 mrem/yr (1.0×10^{-3} LCFs)
Rail			
Railyard worker (member of the public)	0.35 mrem/yr (2.1×10^{-7} LCFs)	35 mrem/yr (2.1×10^{-5} LCFs)	35 mrem/yr (2.1×10^{-5} LCFs)
Nearby resident (member of the public)	2.9×10^{-4} mrem/yr (1.7×10^{-10} LCFs)	0.055 mrem/yr (3.3×10^{-8} LCFs)	0.055 mrem/yr (3.3×10^{-8} LCFs)
Resident near rail stop (member of the public)	0.042 mrem/yr (2.5×10^{-8} LCFs)	8.0 mrem/yr (4.8×10^{-6} LCFs)	8.0 mrem/yr (4.8×10^{-6} LCFs)
Inspector (occupational)	1.9 mrem/yr (9.5×10^{-7} LCFs)	190 mrem/yr (9.5×10^{-5} LCFs)	190 mrem/yr (9.5×10^{-5} LCFs)

The maximally exposed member of the public would be a person working at a service station who would receive a radiation dose of about 19 mrem per year. This is equivalent to a probability of a latent cancer fatality of about 1.1×10^{-5}.

If trains were used to ship the waste, the maximally exposed worker would be an inspector. This worker would receive a radiation dose of about 190 mrem per year. This is equivalent to a probability of a latent cancer fatality of about 9.5×10^{-5}. The maximally exposed member of the public was a railyard worker who was not directly involved with handling the railcars. This person would receive a radiation dose of about 35 mrem per year. This is equivalent to a probability of a latent cancer fatality of about 2.1×10^{-5}.

Alternative B. Table D-18 lists the incident-free radiation doses for the maximally exposed individual scenarios under Alternative B. If trucks were used to ship the waste, the maximally exposed worker would be a driver who would receive a radiation dose of about 2,000 mrem per year based on driving a truck for 1,000 hours per year. This is equivalent to a probability of a latent cancer fatality of about 1.0×10^{-3}.

The maximally exposed member of the public would be a person working at a service station who would receive a radiation dose of about 19 mrem per year. This is equivalent to a probability of a latent cancer fatality of about 1.1×10^{-5}.

If trains were used to ship the waste, the maximally exposed worker would be an inspector. This worker would receive a radiation dose of about 190 mrem per year. This is equivalent to a probability of a latent cancer fatality of about 9.5×10^{-5}. The maximally exposed member of the public was a railyard worker who was not directly involved with handling the railcars. This person would receive a radiation dose of about 35 mrem per year. This is equivalent to a probability of a latent cancer fatality of about 2.1×10^{-5}.

D.7.3 Impacts from Severe Transportation Accidents

In addition to analyzing the radiological and nonradiological risks of transporting radioactive waste from West Valley, DOE assessed the consequences of severe transportation accidents, known as maximum reasonably foreseeable transportation accidents. These severe accidents have a probability of about 1×10^{-7} per year. The consequences of these accidents were determined through the inhalation, groundshine, and immersion pathways.

The following assumptions were used to estimate the consequences of maximum reasonably foreseeable accidents:

- The release height of the plume is 10 meters (33 feet) for both fire- and impact-related accidents. Modeling the heat release rate of accident scenarios involving fire would result in lower consequences than modeling all events with a 10-meter release height.

- Breathing rate for individuals is assumed to be 10,400 cubic meters (13,600 cubic yards) per year (Neuhauser and Kanipe 2000).

- Short-term exposure to airborne contaminants is assumed to be 2 hours.

- Long-term exposure to contamination deposited on the ground is assumed to be 24 hours for the maximally exposed individual and 7 days for the population, with no interdiction or cleanup.

- The accident was assumed to occur in an urban area. The consequences for the maximum reasonably foreseeable accidents were estimated using 2000 census population density data from 0 to 80 kilometers (50 miles) for the 20 most populous urbanized areas in the country.

- Impacts were determined using low wind speeds and stable atmospheric conditions (a wind speed of 0.89 meters per second [2.9 feet per second] and Class F stability). The atmospheric concentrations estimated from these conditions would be exceeded only 5 percent of the time.

- The release fractions used in the analysis were for severity category 6 accidents (see Tables D-5 through D-10).

- The container inventories used in the analysis are listed in Tables D-11 through D-14. The number of containers that were assumed to be involved in the maximum reasonably foreseeable accident are listed in Table D-19. In several cases, multiple Type B shipping containers could be transported in a single shipment (see Table D-2). Because it is unlikely that a severe accident would breach multiple Type B shipping containers, a single Type B shipping container was assumed to be breached in the maximum reasonably foreseeable accident.

No Action Alternative. The maximally exposed individual would receive a radiation dose of 4.6 rem from the maximum reasonably foreseeable transportation accident involving a truck shipment of Class A LLW (Table D-20). This is equivalent to a risk of a latent cancer fatality of about 2.8×10^{-3}. The probability of this accident is about 5×10^{-7} per year. The population would receive a collective radiation dose of about 1,300 person-rem from this truck accident involving Class A LLW. This could result in about 1 latent cancer fatality.

Table D-19. Number of Containers Involved in the Maximum Reasonably Foreseeable Transportation Accident

Case	Mode	Container Type	Number of Containers Involved
Class A LLW drums	Rail	55-gallon drum	168 55-gallon drums
Class A LLW boxes	Rail	B-25 box	28 B-25 boxes
Class A LLW drums	Truck	55-gallon drum	84 55-gallon drums
Class A LLW boxes	Truck	B-25 box	14 B-25 boxes
Class B LLW drums	Rail	55-gallon drum	168 55-gallon drums
Class B LLW HIC	Rail	High-integrity container	1 high-integrity container in one Type B shipping container
Class B LLW drums	Truck	55-gallon drum	84 55-gallon drums
Class B LLW HIC	Truck	High-integrity container	1 high-integrity container in one Type B shipping container
Class C LLW drums	Rail	55-gallon drum	10 55-gallon drums in one Type B shipping container
Class C LLW HIC	Rail	High-integrity container	1 high-integrity container in one Type B shipping container
Class C LLW drums	Truck	55-gallon drum	10 55-gallon drums in one Type B shipping container
Class C LLW HIC	Truck	High-integrity container	1 high-integrity container in one Type B shipping container
Drum Cell Drums	Truck	71-gallon drum	24 71-gallon drums
Drum Cell Drums	Rail	71-gallon drum	96 71-gallon drums
CH-TRU	Rail	55-gallon drum	14 55-gallon drums in one TRUPACT-II Type B shipping container
CH-TRU	Truck	55-gallon drum	14 55-gallon drums in one TRUPACT-II Type B shipping container
RH-TRU	Rail	55-gallon drum	10 55-gallon drums in one Type B shipping container
RH-TRU	Truck	55-gallon drum	10 55-gallon drums in one Type B shipping container
HLW	Rail	Canister	1 canister in one Type B truck shipping container
HLW	Truck	Canister	5 canisters in one Type B rail shipping container

Acronyms: LLW = low-level waste; HIC = high-integrity container; CH-TRU = contact-handled transuranic waste; RH-TRU = remote-handled transuranic waste; HLW = high-level radioactive waste

For the maximum reasonably foreseeable transportation rail accident involving Class A LLW, the maximally exposed individual would receive a radiation dose of about 9.2 rem (Table D-20). This is equivalent to a risk of a latent cancer fatality of about 5.5×10^{-3}. The probability of this accident is about 2×10^{-6} per year. The population would receive a collective radiation dose of about 2,600 person-rem from this rail accident involving Class A LLW. This could result in about 2 latent cancer fatalities.

Alternative A. For waste shipped under Alternative A, the maximum reasonably foreseeable truck or rail transportation accident with the highest consequences would involve CH-TRU waste. Because one transuranic package transporter (TRUPACT-II) shipping container was assumed to be involved in either the truck or rail accident, the consequences for the truck or rail accident are the same. However, the probabilities of the truck and rail accidents are slightly different. The probability of the truck accident was 6×10^{-7} per year; for rail, the probability of the accident was 1×10^{-7} per year. The maximally exposed individual would receive a radiation dose of about 25 rem from this accident (Table D-20),

Table D-20. Consequences of Severe Transportation Accidents[a]

Case	Mode	Severity Category	Individual Dose (rem)	Individual LCF	Population Dose (person-rem)	Population LCF
Class A LLW drums	Rail	6	9.2	5.5×10^{-3}	2,600	1.6
Class A LLW boxes	Rail	6	2.1	1.2×10^{-3}	580	0.35
Class A LLW drums	Truck	6	4.6	2.8×10^{-3}	1,300	0.78
Class A LLW boxes	Truck	6	1.0	6.2×10^{-4}	290	0.18
Class B LLW drums	Rail	6	15	9.2×10^{-3}	4,300	2.6
Class B LLW HIC	Rail	6	9.8×10^{-4}	5.9×10^{-7}	0.30	1.8×10^{-4}
Class B LLW drums	Truck	6	7.7	4.6×10^{-3}	2,200	1.3
Class B LLW HIC	Truck	6	2.5×10^{-4}	1.5×10^{-7}	0.088	5.3×10^{-5}
Class C LLW drums	Rail	6	7.5×10^{-3}	4.5×10^{-6}	2.3	1.4×10^{-3}
Class C LLW HIC	Rail	6	9.8×10^{-3}	5.9×10^{-6}	3.0	1.8×10^{-3}
Class C LLW drums	Truck	6	1.9×10^{-3}	1.1×10^{-6}	0.67	4.0×10^{-4}
Class C LLW HIC	Truck	6	2.5×10^{-3}	1.5×10^{-6}	0.88	5.3×10^{-4}
Drum Cell Drums	Rail	6	0.010	6.1×10^{-6}	2.7	1.6×10^{-3}
Drum Cell Drums	Truck	6	1.8×10^{-3}	1.1×10^{-6}	0.51	3.1×10^{-4}
CH-TRU	Rail	6	25	0.015	6,600	4.0
CH-TRU	Truck	6	25	0.015	6,600	4.0
RH-TRU	Rail	6	0.20	1.2×10^{-4}	55	0.033
RH-TRU	Truck	6	0.045	2.7×10^{-5}	13	7.7×10^{-3}
HLW	Rail	6	0.64	3.8×10^{-4}	170	0.10
HLW	Truck	6	0.013	7.9×10^{-6}	3.6	2.2×10^{-3}

Acronyms: LCF = latent cancer fatality; LLW = low-level waste; HIC = high-integrity container; CH-TRU = contact-handled transuranic waste; RH-TRU = remote-handled transuranic waste; HLW = high-level radioactive waste

a. Impacts are for stable meteorological conditions. Population impacts are in an urban area.

which is equivalent to a latent cancer fatality risk of 0.015. The population would receive a collective radiation dose of approximately 6,600 person-rem from this accident. This could result in about 4 latent cancer fatalities.

Alternative B. For waste shipped under Alternative B, the maximum reasonably foreseeable truck or rail transportation accident with the highest consequences would involve CH-TRU waste. Because one TRUPACT-II shipping container was assumed to be involved in either the truck or rail accident, the consequences for the truck or rail accident are the same. However, the probabilities of the truck and rail accidents are slightly different. The probability of the truck accident was 8×10^{-7} per year; for rail, the probability of the accident was 3×10^{-7} per year. The maximally exposed individual would receive a radiation dose of about 25 rem from this accident (Table D-20), which is equivalent to a latent cancer fatality risk of 0.015. The population would receive a collective radiation dose of approximately 6,600 person-rem from this accident. This could result in about 4 latent cancer fatalities.

Using the screening procedure in *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002c), the sum of fractions of the biota concentration guides for the Class A LLW accidents and the CH-TRU accident were less than 1. Therefore, the radioactive releases from the Class A LLW accidents and the CH-TRU accident are not likely to cause persistent, measurable deleterious changes in populations or communities of terrestrial or aquatic plants or animals.

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